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PROTECTIVE GLASSES AGAINST ATOMIC FLASH

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The advent of nuclear detonations brought many problems to the medical profession. In this paper, however, we shall confine ourselves to the problem of protection from "atomic flash" which occurs with the release of immense energy at the time of the explosion. Much of this energy is released in the form of light -- infrared, visible, and ultraviolet. Roughly speaking, the fireball in its early phase has been described as having a brightness 100 times that of the sun (1). Calculations of the temporal and spectral distribution of the total thermal energy of a nominal yield weapon show that depending on the range, 35 to 40 percent of the radiant energy emitted lies in the visible region of the spectrum (2). It is known that light energy is capable of producing an intraocular burn at distances in excess of hundreds of miles -- depending upon atmospheric attenuation. However, we shall concern ourselves mainly with the problem of protection from "flashblindness" or the temporary inability to discriminate differences in contrast and a resulting lowering of visual acuity that occurs after exposure to intense light of short duration. Time of loss of visual function from high intensity flash has been experimentally established as a linear function of illuminance at the eye (3).

To discuss the multitude of practical operational situations that may occur during nuclear operations would be a lengthy subject unto itself. Rather, we shall merely point out some of the variables that affect production of flashblindness and then set up a reasonably typical

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situation that may occur and discuss some of the techniques and methods that have been applied to reduce or eliminate flashblindness. Let us consider, for the moment, nuclear detonations of nominal yield -- about 20 kilotons. Further, assume an aircraft and crew on a night mission which will take them over friendly and enemy territory. Without complete dependence on radar pickup it is essential that crew members establish and retain a fairly high degree of dark adaptation for visual reconnaissance purposes. The flight profile will require a strike of at least two targets: one primary and one alternate. The flight altitude may vary from 500 feet at target site to over 20,000 feet enroute.

What protective glasses, and here consider glasses any device, are available to the crew? Before attempting to answer this, let us look at the condition from which men must be protected. First, a small body of extremely intense light emitted in all directions, and it is reflected by terrain, almost all physical objects, and clouds which may have a reflectance as high as 80%. Direction of travel away from the point of detonation offers little protection if there is much cloud coverage. Field experiences indicate that loss of orientation due to surrounding flash when flying in clouds is extremely hazardous. In our particular situation it is assumed that separation distance is great enough so that injury from shock blast, ionizing radiation, and thermal radiation, including the eye; that is, retinal burn, is not likely. Our problem of protection is that of shielding from light only.

To a dark adapted eye any light will shift the level of adaptation. Therefore, a device should work, literally, with the speed of light. No

such device exists today. There are, however, devices that can provide adequate protection under the conditions outlined. One such item in development is an electro-mechanical goggle.

Figure 1.

This device is similar in appearance to an old-style aviator's goggle. Alternately opaque and transparent vertical stripes make up the two grids in front of each eye. The opaque stripes ($1\frac{1}{4}$ mm.) are slightly wider than the transparent areas; however, both are less than the pupillary diameter. When open, the opaque stripes are superimposed and 40% of incident light is transmitted. It is somewhat like peering through a picket fence. When actuated by the light detector impulse, a wedge is forcefully directed downward between the two forward grids, displacing them so the opaque stripes on the front grid cover the transparent stripes of the grid behind. This series of events from the time of a beginning flash until closure of the grids where less than .01% of incident light is transmitted is $1/2$ a millisecond. The goggle is manually reopened by rotating the squib cylinder $1/4$ turn. Protection from four flashes is provided. The feasibility of this grid-type device was established in field tests (4).

Devices that may be included in a "fixed density filter" category have been investigated. An adaptation of a standard US Air Force wind blast visor is illustrated in figure 2.

Figure 2.

This particular model is a bidensity type with the denser portion above. A US Navy-developed filter to protect from thermal as well as light energy is illustrated in figure 3. (5)

Figure 3.

The limitation of fixed density filters is that in order to provide the high optical density necessary to protect during flash, not enough light is transmitted to permit vision under ordinary cockpit conditions. We assume in discussing all devices that protection is required from "unexpected" detonations, whether friendly or enemy. This in turn implies that the device must be worn all the time when in the area of a possible detonation.

Electro-optic and magneto-optic devices utilizing the Faraday effect, Maxwell effect, Pockels effect and Piezoelectric effect have been applied in the design of protective glasses. All the aforementioned effects either cause birefringence or affect polarized light being transmitted in such a manner that very marked attenuation of transmitted light through the system is possible. Limitations in using each of the phenomenon have prevented complete acceptance as an eye-protective device. For example, while the Kerr cell principle could be employed to reduce the transmitted light within 5 microseconds, an initial light transmittance of only 15% is possible and the field of view is approximately 7°. In addition, about 20,000 volts is necessary to operate the Kerr cell. Thus, even though the principle is applicable; practically, it cannot be used. However, as new materials and

electronics become available, electro-optic devices will be constantly reviewed in light of these new advances.

Perhaps the most intriguing of all protective methods is that of phototropy. This is a phenomenon, recognized since 1881, whereby absorption of a particular band of the spectrum causes a change of absorption of the material. There are several terms applied to describe the phenomenon, such as photochromism, thermochromism, meta-chromism and phototropism. Collectively, all these terms identify photoreactive materials. Both organic and inorganic materials are photoreactive. Several types of mechanisms may occur to produce a change in phototransmissive and photoabsorptive properties of a material; for example, oxidation reduction reactions, salt isomerization, isomerization from cis to trans state, color or F center formation, and ring closure. Of the types of reactions cited, currently, ring closure is one of the most promising. Although the basic mechanism of why it functions as it does is not well understood, it is described for the spiropyran class of compounds in this way: the photoreactive molecule exists in a bi-planar double ring structure. Upon illumination of near ultraviolet (366 mμ) cleavage of an oxygen-carbon bond occurs and part of the molecule rotates. The molecule then has an open ring and is co-planar and resonance occurs. Filters of photoreactive materials with an optical density of 4.0 or better have been produced (6). Closure time is within microseconds. In order to produce a neutral filter in the "closed" or activated state, a fixed density⁴ filter which absorbs complimentary to the photoreactive materials is

added to make a protective filter because absorption by the spiropyran is selective and does not absorb throughout the entire spectrum (7). Such a combination will have luminous transmittance of 40% in the "open" or unactivated state and will close to .01% luminous transmittance when activated by near ultraviolet. Some filters are reversible within seconds; others are much slower reversing. The reversal is a temperature-dependent function for most compounds.

The photoreactive materials in various solvents are all energy dependent. The more energy incident, the greater the optical density achieved and the faster the density occurs. As we understand it to date, energy dependence of photoreactive materials is an inherent limitation as far as eye-protective devices are concerned.

It was because of this energy-dependence limitation that an actuator system to sense incident illumination and trigger ultraviolet producing gas discharge tubes was developed (8). The actuator system provides energy to activate photoreactive filters. The entire system is to be mounted on the standard Air Force and Navy helmet and will be light weight, compact, and easily removed from eye position when not required. This device has been termed a "flashblindness interim device." A prototype model of the interim device has been tested and it has been proven that the system is feasible. Advanced development is necessary before field testing can be accomplished. While not without limitations, the interim device is one of the most promising devices against flashblindness we have to date.

With continued improvement of this system as a means of protection from flashblindness, protection from permanent retinal damage is assured since more energy is required to burn than flashblind. Provided that photoreactive compounds are developed into practical self-attenuating filters, they no doubt will be widely used in future space vehicles.

REFERENCES

1. Byrnes, V.A., David V.L. Brown, H.W. Rose and Paul A. Cibis.
Retinal burns -- New hazard of the atomic bomb. J.A.M.A.
Vol 157:21-22 (1 Jan 55).
2. Midwest Research Institute. Development of a system to protect
aircraft personnel and equipment from intense thermal radiation.
Final report (NAVY) (3 Feb 60).
3. Metcalf, R.D., and R. E. Horn. Visual recovery times from high
intensity flashes of light. Wright Air Development Center
Technical Report 58-642.
4. Operation PLUMBBOB. Evaluation of eye protection afforded by an
electro-mechanical shutter. ITR-1429, Project 4.2 (Oct 57).
CONFIDENTIAL.
5. Brown, J.L., and J. H. Hill. Navy general purpose light restrictive
goggle specification. Letter Report NM 170112.1, Serial 7278
(23 Sep 58).
6. Report 61-67. School of Aviation Medicine, Brooks AFB, Texas.
7. Van Voorhis, J.J., The National Cash Register Company. Interim
device. Final Engineering Report (1 Feb to 1 Nov 60). Contract
AF 41(657)-322 with the School of Aviation Medicine, Brooks AFB,
Texas.
8. Edgerton, Germeshausen and Grier, Inc. Interim device. Final
Report, Contract AF 41(657)-315 with the School of Aviation
Medicine, Brooks AFB, Texas.